



What is radon?

Radon is a cancer-causing radioactive gas. You cannot see, smell, or taste radon but it may be a problem in your home. When you breathe air-containing radon, you increase your risk of getting lung cancer. In fact, the Surgeon General has warned that radon is the second leading cause of lung cancer in the United States today. If you smoke and your home has high radon levels, your risk of lung cancer is especially high.

Radon (A more scientific description)

Radon is a gaseous highly radioactive element. Discovered by English physicist Ernest Rutherford in 1899. Although the discovery is **also** credited to German physicist Friedrich Ernst Dorn in 1900, it may be fairer to say that Rutherford discovered radon's alpha radiation and that Dorn found that radium was giving off a gas.

Radon is a colorless, chemically unreactive inert gas; it is the densest gas known. The gas and its highly radioactive (radioactivity described) metallic daughter products emit alpha and beta particles and gamma rays. It has been used in the treatment of cancer by radiotherapy. In homes and other buildings, in some areas of the world, radon produced by the radioactive decay of uranium-238 present in soil and rock can reach levels regarded as dangerous. (Chemical Symbol/Element Number: Rn222)

Should you test for radon?

Testing is the only way to know your home's radon levels. There are no immediate symptoms that will alert you to the presence of radon. It typically takes years of exposure before any problems surface and then it is too late.

The U.S. Environmental Protection Agency, Surgeon General, American Lung Association, American Medical Association and National Safety Council all recommend testing your home for radon.

Can you fix the problem?

If you find that your home has high radon levels, there are ways to reduce the concentrations. Even very high levels can be reduced to acceptable levels. Most radon problems can be fixed by a do-it-yourselfer for less than \$500.

RADIATION AND RISK FACTS

The alpha radiation emitted by radon is the exact same alpha radiation that is emitted by any other alpha generating radiation source, like plutonium.

A family whose home has radon levels of 4 pCi/l is exposed to approximately 35 times as much

radiation as the NUCLEAR REGULATORY COMMISSION allows if they were standing next to the fence of a radioactive waste site. (25 mrem limit, 800 mrem exposure)

An elementary school student that spends 8 hours per day and 180 days per year in a classroom with 4 pCi/l of radon will receive nearly 10 times as much radiation as the NUCLEAR REGULATORY COMMISSION allows at the edge of a nuclear power plant. (25 mrem limit, 200 mrem exposure)

Most United States Environmental Protection Agency (EPA) lifetime safety standards for carcinogens are established based on a 1 in 100,000 risk of death. Most scientists agree that the risk of death for radon at 4 pCi/l is approximately 1 in 100. At the 4 pCi/l EPA action guideline level radon carries approximately 1000 times the risk of death as any other EPA carcinogen.

Radon induced lung cancer costs the United States over \$2 Billion dollars per year in both direct and indirect health care costs.

(Based on National Cancer Institute statistics of 14,400 annual radon lung cancer deaths)(Oster, Colditz & Kelley, 1984)

CANCER AND SCIENTIFIC FACTS

CARCINOGENICITY

Radon's primary hazard is caused from inhalation of the gas and its highly radioactive heavy metallic decay products (Polonium, Lead, and Bismuth), which tend to collect on dust in the air. The problem arises when these elements stick to the delicate cells lining the passageways leading into the lungs.

There is sufficient evidence for the carcinogenicity of radon and its isotopic forms, radon-222 and radon-220, in experimental animals. When administered by inhalation, preceded by a single exposure to cerium hydroxide dust, radon induced pulmonary adenomas, adenocarcinomas, invasive mixed adenosquamous carcinomas, and squamous cell carcinomas in male rats. Extrapulmonary metastases occurred in only one animal. Most or all of the tumors were believed to be bronchiolar or bronchio-alveolar in origin. Radon decay products in combination with uranium-ore dust induced a progression of activity from single basal cell hyperplasia in bronchioles to malignant tumors in male hamsters when exposed by inhalation. Lung tumors observed were adenomas, adenocarcinomas, and squamous cell carcinomas; bronchiolar and alveolar metaplasia, adenomatous lesions, fibrosis, and interstitial pneumonia were also observed. When administered by inhalation in combination with decay products, uranium-ore dust, and cigarette smoke, radon-induced nasal carcinomas, epidermoid carcinomas, bronchio-alveolar carcinomas, and fibrosarcoma were observed in dogs of both sexes. In general, a significant increase was observed in respiratory tract tumors in rats and dogs in comparison with unexposed animals. A dose- response relationship was noted in those experiments with rats in which radon was tested. In most instances, tumors at sites other than the lung were not reported, but in one study, mention was made of tumors of the upper lip and urinary tract in rats.

An IARC Working Group reported that there is sufficient evidence for the carcinogenicity of radon and its decay products in humans. Increased incidences of lung cancer have been reported from numerous epidemiologic studies of groups occupationally exposed to high doses of radon, especially underground hard rock miners. These include particularly uranium miners, but also groups of iron-ore and other metal miners, and one group of fluorspar miners. Strong evidence for exposure response relationships has been obtained from several studies, in spite of uncertainties that affect estimates of the exposure of the study populations to radon decay products. Several small case-control studies of lung cancer have suggested a higher risk among individuals living in houses known or presumed to have higher levels of radon and its decay products than among individuals with lower presumed exposure in houses. The evidence on the interaction of radon and its decay products

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with cigarette smoking with regard to lung cancer does not lead to a simple conclusion. The data from the largest study are consistent with a multiplicative or submultiplicative model of synergisms and reject an additive model. In many studies of miners and in one of presumed domestic exposure, small cell cancers accounted for a greater proportion than expected of the lung cancer cases. In one population of uranium miners, this proportion has been declining with the passage of time. Because of the limited scale of epidemiologic studies of nonoccupational exposure to radon decay products available at the time reviews were made, quantification of risk has been based only on data of miners' experience. An IARC Working Group considered that the epidemiologic evidence does not lead to a firm conclusion concerning the interaction between exposure to radon decay products and tobacco smoking. Most of the epidemiologic studies involve small numbers of cases, and the analytical approaches for assessing interaction have been variable and sometimes inadequate.

PROPERTIES

Friedrich Ernst Dorn of Germany discovered radon in 1900. Named after the element "radium" (radon was called niton at first, from the Latin word "nitens" meaning "shining") but has been called radon since 1923. It is an essentially inert, colorless, odorless gas at ordinary temperatures. Its melting point is 202 degrees K and the boiling point is 211 degrees K. When cooled below the freezing point radon exhibits a brilliant phosphorescence which becomes yellow as the temperature is lowered and orange-red at the temperature of liquid air.

The atomic radius is 1.34 angstroms and it is the heaviest known gas, being nine times denser than air. Because it is a single atom gas (unlike oxygen, O₂, which is comprised of two atoms) it easily penetrates many common materials like paper, leather, low density plastic (like plastic bags, etc.) most paints, and building materials like gypsum board (sheetrock), concrete block, mortar, sheathing paper (tarpaper), wood paneling, and most insulation.

Radon is also fairly soluble in water and organic solvents. Although reaction with other compounds is comparatively rare, it is not completely inert and forms stable molecules with highly electronegative materials. Radon is considered a noble gas that occurs in several isotopic forms. Only two are found in significant concentrations in the human environment: radon-222, and radon-220. Radon-222 is a member of the radioactive decay chain of uranium-238, and radon-220 is formed in the decay chain of thorium-232. Radon-222 decays in a sequence of radionuclides called radon decay products, radon daughters, or radon progeny. It is radon-222 that most readily occurs in the environment. Atmospheric releases of radon-222 results in the formation of decay products that are radioisotopes of heavy metals (polonium, lead, bismuth) and rapidly attach to other airborne materials such as dust and other materials facilitating inhalation.

USE

Radon is a noble gas. Only two of its isotopic forms are found in significant concentrations in the human environment: radon-222 and radon-220. Their decay products are not gases and occur as unattached ions or atoms, condensation nuclei, or attached to particles. This decay product of uranium-238 is commonly found in uranium mines. Radon has been used in some spas for presumed medical effects. In addition, radon is used to initiate and influence chemical reactions and as a surface label in the study of surface reactions. It has been obtained by pumping the gases off of a solution of a radium salt, sparking the gas mixture to combine the hydrogen and oxygen, removing the water and carbon dioxide by adsorption, and freezing out the radon.

PRODUCTION

Radon is not produced as a commercial product. Radon is a naturally occurring radioactive gas and comes from the natural breakdown (radioactive decay) of uranium. Most soils contain varying

amounts of uranium. It is usually found in igneous rock and soil, but in some cases well water may also be a source of radon.

EXPOSURE

The primary routes of potential human exposure to radon are inhalation and ingestion. Radon in the ground, groundwater, or building materials enters working and living spaces and disintegrates into its decay products. In comparison with levels in outdoor air, the concentrations of radon and its decay products to which humans are exposed in confined air spaces, particularly in underground work areas such as mines and buildings, are elevated. Although high concentrations of radon in groundwater may contribute to human exposure through ingestion, the radiation dose to the body due to inhalation of radon released from water is usually more important. Concentrations of radon decay products measured in the air of underground mines throughout the world vary by several orders of magnitude. In countries for which data were available, concentrations of radon decay products in underground mines are now typically less than 1000 Bq/m³ EEC Rn (approx. 28 pCi/l). The average radon concentrations in houses are generally much lower than the average radon concentrations in underground ore mines. Workers are exposed to radon in several occupations. Underground uranium miners are exposed to the highest levels of radon and its decay products. Other underground workers and certain mineral processing workers may also be exposed to significant levels. Exhalation of radon from ordinary rock and soils and from radon- rich water can cause significant radon concentrations in tunnels, power stations, caves, public baths, and spas. Peripheral lymphocyte chromosomes from 80 underground uranium miners and 20 male controls in the Colorado plateau were studied. Taken into account were confounding factors such as cigarette smoking and diagnostic radiation. Groups that were increasingly exposed to radon and its decay products were selected. Significantly more chromosomal aberrations were observed among miners with atypical bronchial cell cytology, suspected carcinoma, or carcinoma in situ than among miners with regular or mildly atypical cells, as evaluated by sputum cell cytology.

The Environmental Protection Agency (U.S. EPA) and the Surgeons General's Office have urged widespread testing for radon. They estimated that as many as 20,000 lung cancer deaths are caused each year by radon. Next to smoking, radon is the second leading cause of lung cancer. EPA says that nearly 1 in 3 homes checked in seven states and on three Indian lands had screening levels over 4 pCi/L, the EPA's recommended action level for radon exposure.

Radon is a national environmental health problem. Elevated radon levels have been discovered in virtually every state. The EPA estimates that as many as 8 million homes throughout the country have elevated levels of radon. State surveys to date show that 1 out of 5 homes has elevated radon levels. Radon seeps into homes from the surrounding soil through cracks and other openings in the foundation. Indoor radon has been judged to be the most serious environmental carcinogen to which the general public is exposed and which the EPA must address. Based on current exposure and risk estimates, radon exposure in single-family houses may be a causal factor in as many as 20,000 of the total lung cancer fatalities which occur each year. Radon decay products (polonium- 218 and polonium-214, solid form) can attach to the surface of aerosols, dusts, and smoke particles which may be inhaled, and become deeply lodged or trapped in the lungs. Once lodged, they can radiate and penetrate the cells of mucous membranes, bronchi, and other pulmonary tissues.

Some scientific studies of radon exposure indicate that children may be more sensitive to radon. This may be due to their higher respiration rate and their rapidly dividing cells, which may be more vulnerable to radiation damage.

Radioactivity --- a Summary:

The spontaneous disintegration or decay of the nucleus of an atom by emission of particles, usually accompanied by electromagnetic radiation. Natural radioactivity is exhibited by several elements, including uranium, radium, radon gas, and radon's daughters. The radiation produced is of three types: the alpha particle with relatively weak penetration power, which is a nucleus (two protons and two neutrons) of an ordinary helium atom; the beta particle with moderate penetration power, which is a high-speed electron or, in some cases, a positron (the electron's antiparticle); and gamma radiation, which is a type of electromagnetic radiation with very short wavelengths resulting in very high penetration power. The rate of disintegration of a radioactive substance is commonly designated by its half-life, which is the time required for one half of a given quantity of the substance to decay.

For example, if you had a two liter bottle (think of the large soda bottle in the fridge) that was filled with radon gas and then tightly sealed, at the end of one half-life (approximately 92 hours or almost 4 days) there would only be one liter left in the bottle.

Another issue to consider is the *unusual* property of the radioactive decay chain of uranium/radium/radon. What makes this seem unusual is that a gas is produced from a radioactive solid element (a rock) and then the radioactive gas changes back into radioactive heavy metallic particles. This process and their atomic size (extremely small) make possible the transport of radioactive atoms through a relatively static environment. In other words, radon's extended half-life (it takes about a month for a specific amount of it to decay to almost nothing) provides enough time for the gas to migrate through cracks and crevices in building foundations, then into the internal air volume where it changes into the more harmful radioactive heavy metals. This gas and the resulting very small metallic particles (so small that they will float in air) move quickly through a building or home, contaminating the air. In other words, almost nothing will stop this gas from moving from the basement to other parts of a house if it makes its way into the basement in the first place.

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